

**Title of Project: Advanced MEA's for Enhanced Operating Conditions,
Amenable to High Volume Manufacture**

Contractor: 3M Company, St. Paul, MN

Subcontractors: To be finalized – 3 Universities, 2 Industry

National Lab. Collaborators: BNL, ORNL, LBNL

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Project Duration: 45 months

Estimated Start Date: January 1, 2002

Total Estimated Funding: \$9.0 MM

Technical Goals and Objectives

Development of high performance, lower cost membrane electrode assemblies (MEA's) qualified to meet demanding system operating conditions of higher temperature and little or no humidification, while using less precious metal than current state-of-the-art constructions.

Technical goals include demonstrating:

- Stable MEA operation at $T < \sim 120^\circ\text{C}$ with PFSA type ionomers (lower risk, lower payoff option)
- Development of MEA's for $T > 120^\circ\text{C}$, without using humidified gases (higher risk, higher payoff option)
- MEA materials and processes scaleable to high volumes

Technical Concept

For $T < 120$ C, drier pressurized operation:

Push the envelope with existing materials

- using PFSA's and nanostructured film and other proprietary catalysts
- higher performing cathode catalysts with reduced precious metals
- optimization of gas diffusion layer/current collectors (DCC's)
- air management strategy matched to MEA and flow field design

For $T > 120$ C, dry operation:

Development of MEA based on new PEM

- replacement of PFSA's/water combination for H^+ transport
- gaining and implementing a fundamental understanding of catalyst electrochemical properties *sans* water
- PEM/catalyst interface formation
- understanding and control of stability and degradation mechanisms

Scale-up fabrication processes of MEA components with most promise:

- amenable to high volume
- cost-effective production and component assembly processes
- capable of meeting quality targets

Work Plan Summary

Task 1 is directed at advancing the state-of-the-art in cathode structures and also at stretching the limits of current MEA technology to hotter, drier operating conditions

Subtasks include:

- development of advanced cathode catalysts and membranes based on hydrophilic ionomers;
- matching 3M MEA and air management operating conditions;
- advanced modeling for flow field and gas diffuser optimization;
- optimization of catalyst coated membrane assemblies and DCC's; and
- short stack testing with a subcontractor.

Task 2 focuses on development of high temperature membranes that do not use water from humidified gases for H⁺ transport and matching components to take the MEA into a new operating range of T > 120°C.

Subtasks include:

- development of a high temperature electrolyte membrane and appropriate catalysts;
- optimization of the catalyst membrane interfaces;
- advanced materials characterization and modeling with subcontractors; and
- short stack testing with a subcontractor.

Task 3 is directed at the scale-up and optimization of MEA component fabrication processes amenable to high volume, high quality, low cost production for selected components from Tasks 1 or 2.

Subtasks include:

- scale-up and optimization of the fabrication process for the membrane, catalyst, CCM and DCC.
- MEA's characterized in full-scale (250 cm²) short stacks.

Technical Success – Task 1

Multiple ways to define technical success. One way may be to realize improvements over a pre-contract baseline performance, such as:

1000 hr stability at $T = 115-120^{\circ}\text{C}$, and

Scenario 1: Baseline performance but at half the humidification (25% RH) and one-fourth to one-half the precious metal loading

or

Scenario 2: 50mV gain at all current densities over baseline performance but at the same humidification (50% RH) and no Ru and lower Pt.

where

Baseline Performance: 0.7 V at $CJ = 0.6 \text{ A/cm}^2$, 100°C operation with 50% RH, 2% air bleed, 50 ppm CO in reformat (45% H_2 , 22% CO_2 , 32% N_2), anode stoichiometry = 1.2, cathode stoichiometry = 2.0, 0.44 mg/cm^2 total precious metal.

Technical Success – Task 2

Defining technical success for Task 2 is more speculative because of the higher risk nature of the problems to be solved. Complete technical success will require meeting these challenges:

- Development of a PEM with adequate conductance and stability to operate over a range of temperatures up to 150 C for > 1000 hours.**
- Developing a successful MEA using that PEM.**
- Development of advanced catalysts to shift the PtOH poisoning to meaningfully higher potentials.**